

Gastric acid secretion rate and buffer content of the stomach after a rice- and a wheat-based meal in normal subjects and patients with duodenal ulcer

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SUMMARY The study describes gastric acid secretory response to a rice-based and a wheat-based meal over a prolonged period of five hours and buffer content of the stomach in five normal and seven duodenal ulcer subjects from the rice-eating eastern Indian population. The results suggest that (1) the meal-mediated gastric acid secretory response in duodenal ulcer subjects is much higher than in the controls, even though the histamine stimulated response is similar, (2) the type of meal, whether rice and fish based or wheat and meat based, does not influence the acid secretory response, and (3) the duodenal ulcer subjects in this area, two hours after a meal, have a buffer capacity similar to the controls.

Duodenal ulcer disease in the Indian subcontinent is more common in the rice-eating belt and uncommon in the wheat-eating areas (Malhotra, 1964). Our studies on *in-vitro* hydrogen ion binding by different cereals have shown that cooked whole-wheat flour and cooked bran have a higher hydrogen ion binding capacity than cooked rice (Jalan *et al.*, 1977). In view of these findings, the present study was designed to investigate the gastric acid secretory response and the buffer capacity of the stomach two hours after a meal in five normal and seven duodenal ulcer subjects, to a rice- and a wheat-based meal similar to the ones consumed by the Eastern and Northern Indian people.

Methods

SUBJECTS

The study group consisted of 12 male subjects of whom five acted as controls (mean age 26.4 years, range 21-33 years; mean body weight 53 kg, range 41.3-68.5 kg) and the rest were suffering from duodenal ulcer confirmed by radiology, with no outlet obstruction (mean age 36.8 years, range 30-42 years; mean weight 60.8 kg, range 50.4-74 kg). None of the patients received any treatment before the study.

MEALS

Rice-based meal

This meal, similar to the one commonly consumed by the population of Eastern India, consisted of 100 g of rice boiled in water, 50 g of lean fresh water fish cooked with a very small amount of mustard oil and seasoned with commonly used spices to make a curry, 25 g of lentils boiled in water to make a soup and seasoned with salt and spices, a vegetable preparation containing potato, red pumpkin, cauliflower, and other non-leafy tropical vegetables (raw amount of about 40 g), and 50 g of yoghurt. The subjects were instructed to chew the food thoroughly and swallow it with 300 ml of water in sips. The volume of such a meal on homogenisation was 1000 ml. The carbohydrate, protein, and fat content of the meal was 105 g, 29 g, and 15 g respectively. The total calories added up to 680 Kcal.

Wheat-based meal

This meal, consumed mainly in the North and North West India and similar to the rice meal, had 100 g whole-wheat flour made into chapatties (a local preparation of unleavened bread) in place of rice. Fish was replaced by 50 g of goat meat. The total volume of such a meal on homogenisation was 800 ml and the calculated amounts of carbohydrate,

protein, and fat were 101 g, 32.5 g and 26 g respectively. The calorie content of the meal was 723 Kcal.

Acid secretion rate after a meal

The method of measuring gastric acid secretion rate in response to meals was as described by Fordtran and Walsh (1973) except that the measurements were continued up to a period of five hours after the meal. The principle of the test involves *in-vivo* titration of the gastric acid with 0.3 N sodium bicarbonate solution so as to maintain the gastric pH at 5.5. The amount of bicarbonate required per hour is equal to the rate of the net acid secretion. The subjects were intubated after a 10 hour fast with 16 Fr. Levin's tube to which was attached a small polyvinyl tube (ID 1 mm) opening 10 cm proximal to the ports of the Levin's tube. The tube was positioned under fluoroscopic control in such a manner that the opening of the Levin's tube was at the antrum and the lower part of the body of the stomach, while the opening of the polyvinyl tube was in the upper part of the body of the stomach. The pH of the residual gastric contents was checked and brought to 5.5, if required, by infusing 0.3 N sodium bicarbonate through the side tube by a Holter pump. The subjects were then asked to consume the meal, which they took 20-30 minutes to eat. During and after the meal the rate of the bicarbonate infusion was further adjusted every two minutes to maintain the gastric pH at 5.5. When the meal was finished the subjects lay in a recumbent position and the average sampling rate was once every two minutes. Care was taken to achieve proper mixing in the stomach by measures outlined by Fordtran and Walsh (1973). The pH was measured by a Phillips pH meter using a combined electrode. The maximal acid response to a meal was defined as the highest secretion in any one hour period after eating.

MEASUREMENT OF BUFFERING CAPACITY OF STOMACH

The buffer capacity was again measured in a manner described by Fordtran and Walsh (1973) on separate days with similar meals. Thirty minutes after ingestion of the meal the subjects were intubated, gastric contents mixed and sampled for pH determination as described above. One hour after the meal 0.1 N HCl was infused, if required, in order to lower the pH, so that, at two hours, the intragastric pH was 2.5 or below. At two hours 0.3 N NaHCO₃ was rapidly infused into the stomach and pH of the gastric content was monitored at frequent intervals until it reached 6 and the cumulative volume of bicarbonate infused was recorded each time a sample was withdrawn. The average time of alkalin-

sation for rice meal and wheat meal was 15 and 13.5 minutes respectively. A titration curve was plotted for each experiment and the amount of bicarbonate required to raise the pH from 2.5 to 5.25 was read out from the titration curve. This amount of bicarbonate was taken to be the buffer capacity at two hours after a meal. The total buffer content of the rice and the wheat meals was 70 mmol and 110 mmol respectively, as determined by *in-vitro* titration of the meals consumed by the patients.

BASAL AND MAXIMAL HISTAMINE RESPONSE

This was determined by methods described earlier (Jalan *et al.*, 1978); 0.04 mg per kg body weight of histamine acid phosphate was used as we found that this dose consistently produced maximal gastric acid secretion both in the controls and the duodenal ulcer subjects (Jalan *et al.*, 1978). Maximal acid output to histamine was taken as the total output over the first hour after administration of histamine (Card and Marks, 1960).

Results

ACID SECRETION RATE AFTER EATING

Figure 1 shows that the average basal secretion in control and duodenal ulcer subjects was 4.60 mmol and 7.48 mmol per hour respectively. The acid secretion promptly started rising after the meal and a sustained rate of acid secretion was maintained

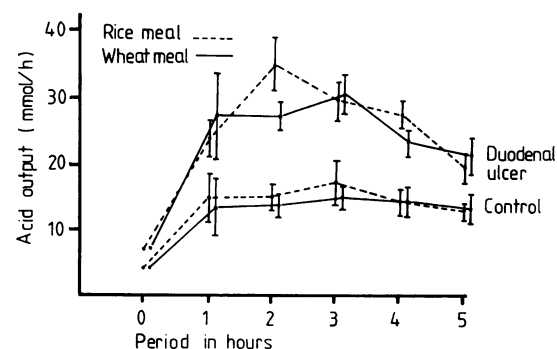


Fig. 1 Rate of acid secretion after eating a rice based and wheat based meal in the control and duodenal ulcer subjects.

throughout the period of the study. No sharp peak of acid secretion was noted except in duodenal ulcer subjects after a rice meal, where a peak was observed at the end of the second hour. The maximal acid secretory response in individual subjects after a rice meal when compared with that after a wheat meal showed a good correlation taking both the

control and duodenal ulcer subjects together ($n = 12$, $r = 0.77$, $p < 0.01$).

The majority of duodenal ulcer subjects secreted in response to a meal at a rate (mean \pm SE (mmol/h) rice meal— 38.71 ± 3.41 , wheat meal— 38.28 ± 3.04) nearly double the maximal histamine response (20.07 ± 1.68), whereas in the controls this was nearly the same (histamine— 22.66 ± 3.78 , rice meal— 21.4 ± 3.13 , wheat meal— 20.0 ± 2.38). The relation between the maximal histamine and maximal meal acid response is shown in Fig. 2. Although there is a good correlation between the responses in the controls, none was evident in the duodenal ulcer subjects.

BUFFER CAPACITY OF STOMACH

The average buffer capacity after a wheat meal was 29 mmol in controls and 40 mmol in duodenal ulcer patients, whereas, after a rice meal, it was 23.6 mmol and 30 mmol respectively. Higher buffer capacity after the wheat meal (Fig. 3) is likely to be a reflection of the higher buffer content of the wheat meal itself, but when expressed as a proportion of the total buffer in the meal more buffer is emptied after the wheat meal than the rice meal.

The inverse relationship between the buffering capacity and the maximal acid secretory response as shown by Fordtran and Walsh (1973) was not evident in our subjects (Fig. 4). Although a statistically significant positive correlation was not seen in the combined group of duodenal ulcer and control subjects either after a wheat meal or after a rice meal, a trend towards such a direct relationship was evident.

All the controls required infusion of 0.1 N HCl from one to two hours after the meal to keep the pH below 2.5, irrespective of the type of meal

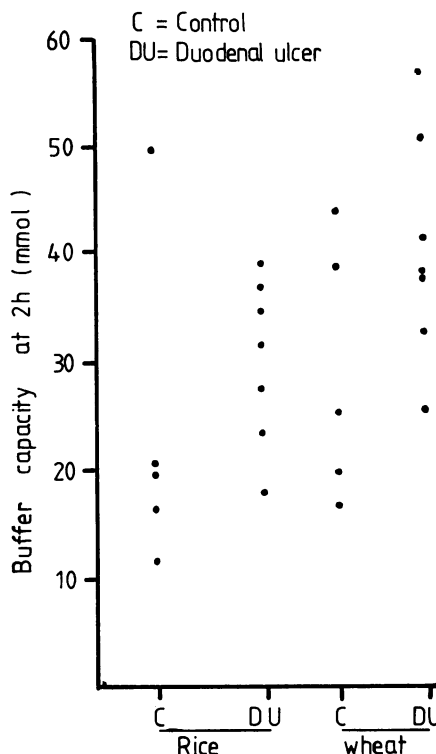


Fig. 3 Buffer content of the stomach two hour after beginning the rice based and wheat based meal in control and duodenal ulcer subjects.

consumed. However, a few duodenal ulcer subjects did not require any and the amount of acid required in the rest was lower than that in the controls. With the wheat-based meal the amount of 0.1 N HCl required in duodenal ulcer subjects as well as in

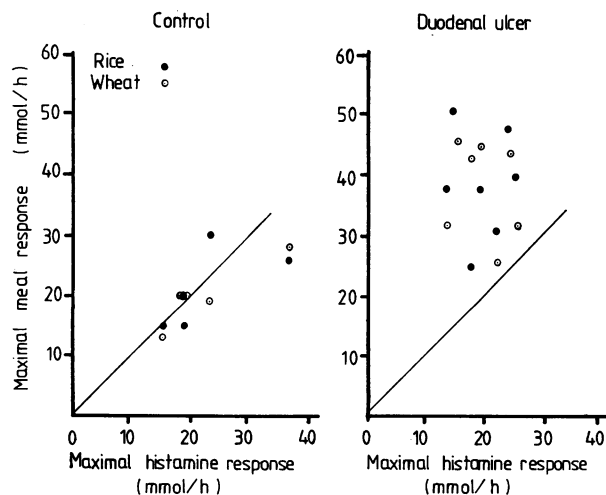


Fig. 2 Correlation of peak histamine and peak meal response to a rice based and wheat based meal in control ($r = 0.73$) and duodenal ulcer subjects.

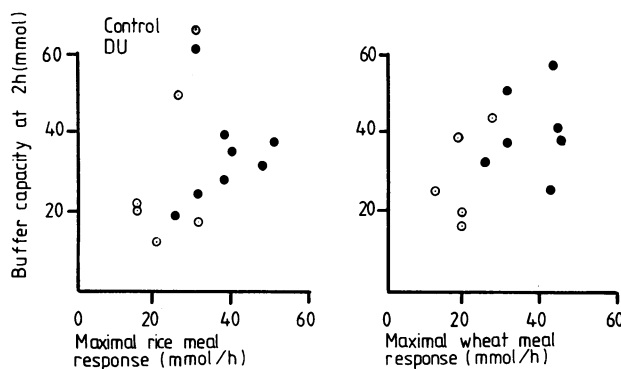


Fig. 4 Correlation of the buffer content and peak meal response to rice based ($r = 0.51$, $0.05 > P > 0.1$) and wheat based meal ($r = 0.51$, $0.05 > P > 0.1$) in control and duodenal ulcer subjects.

the controls was higher, but the difference did not assume statistical significance (mean \pm SE, HCl infused (ml): Control, rice— 149.9 ± 51.8 , wheat— 190.24 ± 45.08 ; duodenal ulcer—rice 29.3 ± 15.33 , wheat 62.2 ± 25.18).

Discussion

This study shows that the meal-stimulated acid secretory response in duodenal ulcer subjects was on the average double the peak histamine response, whereas in the controls it was similar. These results are similar to those obtained by Fordtran and Walsh (1973) in their duodenal ulcer subjects, the responses, however, being of higher magnitude. As the maximal secretory responses to histamine of the duodenal ulcer patients chosen for study were very close to those in the controls, the differences between the duodenal ulcer subjects and the controls with respect to maximal acid secretory response to both types of meal cannot entirely be accounted for on the basis of duodenal ulcer subjects requiring more bicarbonate infusion. Nor could this higher response to the meal be due to our having used a submaximal dose of histamine, as we have already shown (Jalan *et al.*, 1978) that the population under study consistently produces peak rates of acid secretion to a dose of 0.04 mg/kg of histamine acid phosphate unlike the findings of Desai *et al.* (1967, 1969). Findings of the present study suggest that the meal-mediated gastric acid secretory response—a result perhaps of various factors such as parietal cell responsiveness, increased vagal tone, and increased gastrin response—has a more significant bearing on the pathogenesis of duodenal ulcer in this population than the so-called maximal gastric acid secretion observed after administration of exogenous stimuli such as histamine, pentagastrin, and insulin. It also appears that the meal-stimulated

acid secretory responses are better discriminants between ulcer and non-ulcer subjects than the augmented histamine test.

Our results on the buffer capacity of the stomach, two hours after a meal are at variance with those of Fordtran and Walsh (1973) who have shown a more rapid emptying of buffer after a meal in duodenal ulcer subjects. We could not demonstrate a statistically significant difference in the buffering capacity of the stomach between our duodenal ulcer subjects and controls. These findings are in keeping with those of Howlett *et al.* (1976) who studied gastric emptying after a solid meal in duodenal ulcer patients. Applying the mathematical technique of principal component analysis to their data, they could clearly separate these patients into two groups—that is, one with a rate of gastric emptying similar to that of the controls (like our subjects) and the other with an increased rate of gastric emptying similar to the subjects studied by Fordtran and Walsh. Similar findings have also been reported by Hunt (1957), Brömster *et al.* (1966), and George (1968). It should, however, be emphasised that the method of Fordtran and Walsh (1973), which has been used by us, measures only the emptying rate of buffer and not necessarily the emptying rate of the total mass in the stomach. It is to be noted that both the control as well as the duodenal ulcer subjects emptied their wheat meal buffer more rapidly than the rice meal. This could be because the volume of the wheat meal was smaller. The well-known square root relationship of gastric emptying to meal volume implies that the higher the meal volume, the slower is the gastric emptying and *vice versa* (Hopkins, 1966).

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